APPENDIX D

Project Operations

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Appendix D

Project Operations

D.1 Introduction

The Species Conservation Habitat (SCH) ponds are intended to be operated in a manner that would both provide a partial in-kind replacement for some of the near-term habitat losses at the Salton Sea (the Sea) and answer key questions regarding the development of shallow-water habitat as part of a long-term restoration program at the Sea. Operations of the Salton Sea SCH Project (Project) components would have to balance habitat requirements necessary to achieve desired objectives against competing constraints such as environmental limitations (physical, water quality, and climatological conditions); compatibility with existing and future adjacent land uses (agricultural fields, geothermal development, and other habitat projects at the Sonny Bono Salton Sea National Wildlife Refuge); and habitat values (at the refuge); and consistency with the applicable requirements of the Imperial Irrigation District (IID) Habitat Conservation Plan/Natural Communities Conservation Plan. Decisions necessary to strike this balance and meet the objectives would be made within an adaptive management framework.

This appendix provides a conceptual overview of the range of operations that could be used to provide suitable habitat (for species dependent on the Salton Sea) and to test different operational scenarios as part of the “proof-of-concept” aspect of the SCH Project. Key indicators of physical, chemical, and biological attributes of that habitat would be monitored to determine the effects of different operational scenarios, and any adjustments would be implemented as needed in accordance with the SCH Monitoring and Adaptive Management Framework, as described in Appendix E.

D.2 Key Project Components

The general facilities necessary for each alternative include river water diversion, sedimentation basin, saline water diversion, SCH ponds, in-pond habitat features, and an agricultural drain interception ditch.

D.2.1 River Water Diversion

River water would be diverted for the use of producing shallow-water aquatic habitat in one of two manners. For Alternatives 1 and 4, river water would be diverted via a lateral weir placed on the edge of the river channel. The diversion weir would be located upstream of the SCH ponds to provide sufficient hydraulic head to convey the water to the SCH ponds with gravity. For Alternatives 2, 3, 5, and 6, river water would be diverted via electrically driven pumps located adjacent to the SCH ponds.

D.2.2 Sedimentation Basin

Waters in the New and Alamo rivers contain suspended sediment that would need to be removed prior to conveyance and delivery to the SCH habitat ponds. The concentration of the suspended sediment in the rivers is recently reported at about 219 milligrams per liter (mg/L) for the New River and 280 mg/L for the Alamo River. The water diverted to the SCH ponds from the rivers would have to go through a sedimentation basin to remove the sediment load before the water is released to the SCH ponds. For alternatives using a gravity diversion, the sedimentation basin would be located upstream of the SCH ponds near the point of diversion. For alternatives using the pumped diversion, the sedimentation basin would be located within the SCH pond footprint.

The sedimentation basin would be operated to hold the water just long enough for the sediment to settle out. The settling time is a function of the size of the particles suspended in the water column.

Sedimentation basins elsewhere in the Imperial Valley store water for about 5 days. Routine operations would include the removal and disposal of the sediments collected in the sedimentation basin. The frequency of these actions and amount of material to be removed would be determined once an alternative were selected for design and could be modified during the life of the SCH Project as a result of sediment control measures being independently implemented as part of the Clean Water Act Section 303(d) requirements (Total Maximum Daily Loads).

D.2.3 Saline Water Diversion

Saline water would be diverted by electrically driven pumps placed on a structure in or adjacent to the Salton Sea to produce the desired salinity in the SCH ponds. The water must be pumped (lifted) because the Sea's elevation Sea is less than the desired pond elevation of -228 feet mean sea level (msl). Currently, the water would have to be lifted about 4 feet in elevation from the Sea to the SCH ponds. As the Sea's elevation declines over time, the height that the saline water would have to be lifted would increase, along with the distance that the water had to be conveyed to reach the ponds.

D.2.4 SCH Pond Berms

The SCH pond complex would be formed by constructing low height (up to approximately 8-foot-high) berms to contain water and separate the SCH ponds from the remainder of the Salton Sea and its recently exposed playa. Internal berms would segment the SCH ponds into experimental units.

The SCH ponds would be constructed primarily on recently exposed playa following the existing topography (ground-surface contours) where possible. The ground surface within the SCH ponds would be excavated (with a balance between cut and fill) to acquire material to build the berms and habitat islands. The borrow areas for the berms would generally form adjacent channels, swale channels, and shallow excavations. The maximum water surface elevation would be -228 feet msl. Pond depth would range from near zero toward the shoreline (-228 msl) to 6 feet at the exterior berm. Maximum depth in excavated areas would be up to 10 feet. Outflow structures would be constructed in the outer berms, and maximum outflow from the SCH pond complex to the Salton Sea would total approximately 130 cubic feet per second.

Berms would be maintained to repair damage due to structural failures, differential settling, surface erosion, access, and water management functions. Berms may require future strengthening by others to accommodate other compatible land uses (e.g., geothermal development).

D.2.5 In-Pond Habitat Features

Several constructed bird and fish habitat structures would be included in the SCH ponds, such as swales, holes, and habitat islands. Swales are 2-foot or deeper channels within the pond units that would be constructed with scrapers and excavators. They ultimately would serve as habitat features to increase aquatic habitat heterogeneity, connect shallow and deep areas of a pond unit, and provide deeper refugia near shallow areas. Each SCH pond would include several islands for bird habitat: one to three nesting islands (suitable for tern species) and three to six smaller roosting islands (suitable for cormorants and pelicans). The overall SCH pond complex could also include one or more large (2- to 10-acre) islands that have rocky and sandy substrate (suitable for cormorant nesting).

D.2.6 Agricultural Drain Interception Ditch

Water from adjacent agricultural drains that currently flows (or is pumped) directly into the Salton Sea would be rerouted around the SCH ponds. The interception ditch would allow for the continuation connection of these drains to the Salton Sea and not disturb the flow of agricultural drainwater from the adjacent fiel ds. IID woul d maintain operational cont rol of these drains and continue to provide all maintenance activities necessary on these drains.

D.3 Operational Variables and Range

D.3.1 Habitat Requirements and Operational Constraints

SCH ponds are intended to:

- Provide habitat suitable for production of fish dependent on the Salton Sea. Likely fish candidates are one or more varieties of tilapia, which are an important forage species for fish-eating birds. Other fishes that could become established in the SCH ponds include desert pupfish (*Cyprinodon macularius*), sailfin mollies (*Poecilia latipinna*), mosquitofish (*Gambusia affinis*), and threadfin shad (*Dorosoma petenense*).
- Provide habitat suitable to support fish-eating birds and other birds dependent on the Salton Sea. Foraging habitat would be a key attribute, but other features to meet habitat needs for nesting and resting would also be included.

SCH pond o perations would attem pt to meet Project goals and objectives given certain constraints of physical conditions, water qualit y, an d clim ate. The ge neral characteristi cs of the aquatic habitat that would likely be present for fish include:

- Highly eutrophic, shallow-water ponds that would be highly turbid in spring through fall.
- Low temperatures below 50 degrees Fahrenheit (°F) (10 degrees Celcius [°C]) during short periods of the winter and high temperatures in the low–to mid 90s °F (low 30s °C) in the late spring through early fall.
- Dissolved oxygen (DO) concentrations ranging from zero mg/L at the mudline to super-saturated during daylight hours in spring to fall.

SCH Project operations would be constrained b y th e physical characte ristics of the ponds (e.g., depth, area, and bot tom profile), but certain w ater quality conditions cou ld be m odified, within so me range of conditions, as needed, by adjusting t he li mited opera tional controls to create more desirable habitat conditions in the ponds. The primary operational variables that could be controlled are:

- Salinity of the water within the ponds;
- Volume of water in the ponds;
- Residence time of the water in the ponds;
- Pond depth;
- Fish species stocked in the ponds; and
- Physical cover elements.

Depending on the specific alternative and p ond design selected, the habitat would be com posed of a few to several individual ponds. This design would allow the operators to tr y different com binations of storage, salinity, and residence times to investigate how these factors could be adjusted to provide the best conditions for fish and birds. Di fferent operational scenarios would be tested during the proof-of-concept phase, the fir st 10 y ears of Project oper ation (to approxim ately 2025). After the proof-of-concept phase, pond variables would be managed to produce the best habitat for fish and wildlife dependent on the Salton Sea.

The following discussion is based on the construction and operation of approximately 2,400 acres of habitat, but the acreage could be less or more depending on the alternative selected and the funding available for Project construction.

D.3.2 Salinity of Stored Water

The SCH ponds would typically be operated within the range of 20 to 40 parts per thousand (ppt) salinity. Water from the Alamo River or New River (salinity approximately 2 ppt) would be blended with water from the Salton Sea (current[1] salinity approximately 53 ppt) to produce the desired pond salinity. Blending the river water and seawater in different amounts would allow for a range of salinities to be used in the ponds.[2]

Different ponds could be operated under different salinities to test which salinity regime results in the best combination, or balance, of invertebrate and fish productivity, bird use, seasonal fish survival, and exposure to selenium (Figure D-1). For example, cold tolerance by tilapia is better at lower salinities (20 ppt) than at higher salinities (60 ppt) (Lorenzi and Schlenk, in preparation), but selenium loading to the pond is increased (more river water equals lower salinity but higher inputs of water-borne selenium) (Appendix I, Selenium Management Strategies). Salinity in the ponds could also be increased as needed to control mosquito populations (Appendix F, Mosquito Control Plan), control emergent vegetation growth (Table D-1), and limit the development of aquatic habitat that would support freshwater fish known to be predators of desert pupfish.

During the proof-of-concept phase, salinities would be typically managed between 20 to 40 ppt. This range is generally sufficient to control many of the negative factors listed above and within the range to be tolerated by the fish species expected to be used in the SCH ponds. Pond salinity may be allowed to exceed this general range (from undiluted river water [2 ppt] up to 50 ppt) in the course of balancing evaporation and water pumping, or if deemed appropriate to test specific fish management or habitat value hypotheses. For example, it may be desirable to operate each pond at a different salinity (e.g., undiluted river water, 20 ppt, and 40 ppt) and monitor biological outcomes and long-term operational feasibility. SCH ponds would not be operated with hypersaline conditions (greater than 50 ppt) because they would result in decreased viability of the desired aquatic habitat.

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[1] The salinity in the Salton Sea is expected to increase in the future, with salinity exceeding 100,000 ppt by 2030 (DWR and DFG 2007).

[2] Evapoconcentration, increasing the salinity through the evaporation process, was simulated in the water quality modeling for this Project and found to be ineffective in achieving the desired salinity range in a short period of time.

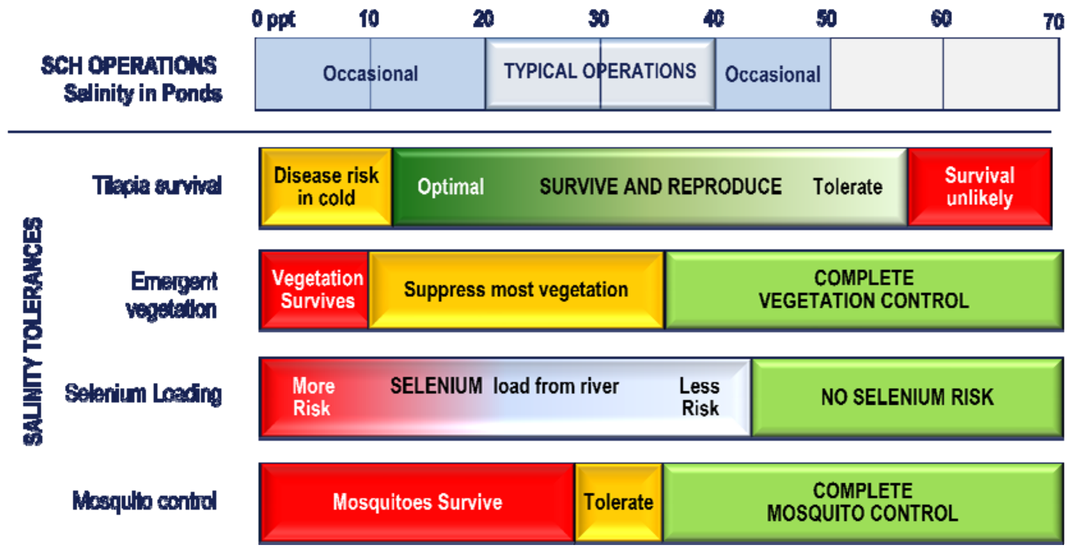

Figure D-1 Operational Range of Salinities and Biological Constraints

Table D-1 Salinity Tolerances of Local Plant Species

Species	Habitat	Typical Salinity Preference	Widest Salinity Tolerated	Comments and Sources
California Bulrush (*Schoenoplectus californicus*)	Widespread in fresh and intermediate marsh zone	0-3.5 ppt	Approximately 10 ppt or greater will control populations	Stutzenbaker 1999 Prolonged exposure to extreme conditions (15-20 ppt) exceeds the typical salinity tolerance and populations decline (Louisiana Coastal Wetlands Conservation and Restoration Task Force 2002)
American Bulrush (*Scirpus americanus*) Olney's three-square bulrush (*Schoenoplectus americanus*)	Fresh to intermediate marshes	0-3.5 ppt	50% reduction at 4 ppt and no germination above 13 ppt	Stutzenbaker 1999; Uchytil 1992 Management and maintenance depends primarily on maintenance of water levels and secondarily on salinity levels (Uchytil 1992)
Saltmarsh Bulrush (*Scirpus maritimus* or *Scirpus robustus*)	Intermediate to brackish marshes, often on soils subject to tidal influence	3.5-10 ppt	Has been found in hypersaline lakes (~60 ppt) Germination reduced 50% at salinity = 9 ppt. No germination at salinity = 21 ppt.	Stutzenbaker 1999; International Lake Environment Committee 1998; Snyder 1991
Broad Leaf Cattail (*Typha latifolia*)	Freshwater aquatic normally, but also found in intermediate marshes	0-0.5 ppt	Found in intermediate marshes with salinity up to 3.5 ppt In marshes of southeastern Louisiana, occurred at salt levels up to 1.13%	Stutzenbaker 1999
Narrow Leaf Cattail (*Typha angustifolia*)	Freshwater aquatic normally, but also found in intermediate marshes; coastal	0-0.5 ppt	15-30 ppt	Stutzenbaker1999; Reed et al.1995
Southern Cattail (*Typha domingensis*)	Wetlands ranging from fresh to brackish	0-10 ppt	75% mortality occurred at 15 ppt	Stutzenbaker 1999; Glenn et al. 1995

D.3.3 Volume of Water in Storage

Storage is the amount of water contained in the SCH ponds at a given time. The volume that could be stored would depend upon the size of the ponds, which varies by alternative. The storage would also be controlled by changing the inflow and outflow to the SCH ponds. A pond could be operated at a constant storage or varying storage, depending on the proof-of-concept testing. Reasons for varying storage (and hence the maximum depth and inundated area) include responding to water quality conditions, desire to create different habitat conditions in the pond (e.g., shallow-water habitat), vector control, or pond maintenance.

Water quality modeling performed for the SCH Project has shown that DO or temperature conditions respond to several operational parameters, including the depth of the water in a pond and pond shape (the relationship between water depth and surface area). Therefore, changing storage in the pond can alter these conditions by changing the amount of shallow- and deepwater habitat.

The storage could be operated at any amount from empty (e.g., for emergency maintenance) to full with a maximum depth of approximately 6 feet at the terminal berm. Should the average depth of the pond be 3 feet, the storage at full depth would be approximately 7,200 acre-feet for a constructed pond complex of 2,400 acres. Operators would determine the appropriate depth and manage the total storage in the pond to meet that depth.

D.3.4 Residence Time

Residence time is a measure of the time it would take the average unit of water volume to pass through the SCH ponds (or loss to evaporation). The residence time defines the amount of water diverted from the river and the Sea and in turn controls the diversion facilities, Project energy use, and cost. Residence time may be an important parameter for the control of habitat conditions in the SCH operations.

SCH pond residence time would be altered as a result of other operations of the SCH ponds or could be an experimental variable for operational testing. Residence time may vary in response to climatic conditions (including temperature, wind frequency, direction and speed, and solar illumination) or may be modified to test various hypotheses regarding the habitat value during differing climatic conditions and to control anticipated negative conditions. These negative conditions would include the increased probability of depleted DO concentration (anoxia) in portions of the water column or pond areas.

During the Project's proof-of-concept phase, pond residence time would be managed to test the hypotheses developed through the use of the adaptive management process (see Appendix E). Based on preliminary water quality modeling results (see Appendix J, Summary of Special Studies Supporting the EIS/EIR Impact Analysis), it is anticipated that residence times could vary from a couple of weeks (2 weeks) to several months (32 weeks). This range is generally sufficient to support the proof-of-concept testing while allowing for the control of potential negative factors and the production of the desired habitat.

D.3.5 Pond Depth

The maximum and average depth of water in the SCH ponds would be varied to test various hypotheses regarding habitat value during differing climatic conditions and to control anticipated negative conditions listed above for residence time. Depth also could be controlled to manage predation on the fish in the ponds. Different ponds could be operated at different depths, and pond depth could be changed to test different scenarios. A range of depths would be created through excavation of material used for berms. The depth (and pond area) could also be changed by varying the amount of water stored in a pond during the year.

During the Project's proof-of-concept phase, pond depth would be managed to test the hypotheses developed through the use of the adaptive management process (see Appendix F). Based on preliminary water quality modeling results (see Appendix J), it is anticipated that the maximum pond depth at the edge of the berms would be 6 feet. Pond depth may be managed outside this general range to test specific fish management or habitat value hypotheses. Ponds may need to be drained or the elevation lowered for emergency maintenance or to control aquatic conditions, but this drainage would not be a routine occurrence.

D.3.6 Fish Stocking in Ponds

Fish Species Selection

The SCH ponds would be designed to support fish to serve as prey for piscivorous birds. Promising candidate species must be able to forage, grow, and reproduce in fluctuating salinities using the soft, finegrained sediment that would naturally form the pond substrate. Fish that have evolved to deal with environmental fluctuations would be better able to thrive in SCH ponds than those whose physiology is less plastic when dealing with environmental extremes.

A number of species present in riverine or estuarine habitats of Southern California and Baja California, Mexico, could be suitable candidates for a productive SCH fish community (DFG 2011). The main attributes considered were foraging suitability for a wide range of piscivorous birds (e.g., no "bottom-hugging" flatfish that would be inaccessible to most birds), resistance to perturbation (e.g., tolerates wide fluctuations in temperature, DO, salinity), high productivity, and sustainability. These attributes were weighed against potential risk to desert pupfish, potential risk for spread to new habitats not currently occupied, and difficulty or expense in obtaining or producing sufficient numbers for stocking. For the Project's initial establishment, however, only those species currently inhabiting the Salton Sea and its connected waters would be considered for use. Desert pupfish, a federally protected species, are present around the Salton Sea and would be included in the SCH ponds. Selecting only fish species that currently reside at the Sea would avoid any new impacts beyond what the Salton Sea desert pupfish population is currently exposed.

Therefore, the fish assemblage proposed for initial deliberate introduction into the SCH ponds would include one or more forms of tilapia and possibly threadfin shad, as well as desert pupfish, sailfin molly, and mosquitofish. Stocking more than one fish species in the ponds would provide some redundancy and improve sustainability of the fish community. If these initial species do not meet the Project objectives, other candidate species evaluated by DFG (DFG 2011) would be considered.

Tilapia

Tilapia satisfy the entire suite of attributes sought in a candidate species, more than any other single species being considered for the SCH Project (DFG 2011). This family of fishes has wide tolerances for water quality conditions, flexible diet including algae and invertebrates, high fecundity, and distribution throughout the water column. Furthermore, they could also support sport fishing. This species is highly tolerant of a wide range of salinities, including high salinities, as demonstrated by their current dominance in the hypersaline Salton Sea. Juvenile Mozambique hybrids can be slowly acclimated up to 95 grams per liter and survive at least for 5 days if the temperature is kept constant at 73 to 77 °F (23 to 25 °C) (Sardella et al. 2004a). Tilapia are less capable of dealing with high salinity under extreme temperatures (Sardella et al. 2004b). The preferred temperature range for optimum tilapia growth is 82° to 86°F (28 to 30°C). Growth diminishes significantly at temperatures below 68°F (20°C) and death would occur below 50°F (10°C) (Rakocy and McGinty 1998). At temperatures below 54°F (12°C), tilapia are more vulnerable to infections by bacteria, fungi, and parasites. The temperature regime in the SCH ponds would be expected to be more extreme than that of the current lake (DWR and DFG 2007). Models of water temperatures for the SCH ponds predict temperatures below the lethal threshhold for Mozambique hybrid tilapia (Appendix J).

Tilapia are remarkably tolerant of low DO concentrations, considerably below tolerance limits for most fish. Tilapia can thrive at DO concentrations of 2 mg/L, can survive extended periods of 1 mg/L, and can tolerate routine dawn DO concentrations of less than 0.3 mg/L (Popma and Masser 1999). In low DO conditions, fish frequently are found near the surface taking in water in the thin surficial layer that remains somewhat oxygenated (personal communication, K. Fitzsimmons 2010). Such behavioral coping responses could increase the vulnerability of fish to bird predation near the surface.

Their main drawback, other than potential competition with desert pupfish, is whether they could handle the lowest water temperatures predicted for SCH ponds. Stocking different tilapia species or strains (individually or in combination) among the SCH ponds could test which species is most sustainable and resilient, and could enhance stability of the fishery resource in the ponds in the face of seasonal and annual fluctuations in water quality parameters. The three tilapia species under consideration for stocking in the SCH ponds include the following:

California Mozambique Hybrid Tilapia – California Mozambique hybrid tilapia ("Mozambique tilapia") are a hybrid of *Oreochromis mossambicus* and *O. urolepis hornorum*. This species is currently the dominant species in the Salton Sea and is widely used in aquaculture including at fish farms in the Salton Sea watershed. Advantages of this species are its demonstrated ability to survive, thrive, and achieve high productivity in hypersaline conditions, as well as its presumed importance as a suitable forage fish for all piscivorous birds at the Salton Sea. The risk from using Mozambique tilapia as the sole forage species is the potential for population crashes, as seen with the massive fish die-offs at the beginning of the decade. The proposed SCH operations would be designed to keep water quality conditions within known tolerances and, therefore, population fluctuations may be dampened.

Blue Tilapia – Blue tilapia (*Oreochromis aureus*) have a lower tolerance for salinity, but handle colder temperatures than the other two tilapia (Popma and Masser 1999). Tilapia resembling blue tilapia are currently only present in the New and Alamo rivers. The genetic makeup of this tilapia assemblage is uncertain, but likely includes *O. aureus* and possibly Mozambique tilapia genetic material given the checkered history of tilapia introductions and movements in southern California (personal communication, K. Fitzsimmons 2010).

Redbelly Tilapia – Redbelly tilapia (*Tilapia zillii*) were once the dominant tilapia species in the Salton Sea, when salinity was lower. Although they were replaced by the Mozambique tilapia, they are still thriving in some of the agricultural drains. The difference in their tolerance to salinity and temperature, as well as a different breeding strategy, may provide plasticity in response to perturbation for a fish community that contains both species.

The relative tolerances of these species to combinations of salinities (20 ppt, 45 ppt, and 60 ppt) and temperatures (cold 11-16°C [52-61 °F]), warm 23-28°C [73-82 °F], and hot 33-38°C [91-100°F]) were tested experimentally (Lorenzi and Schlenk, in preparation). The tested fish included Mozambique tilapia (two strains: wild fish from Salton Sea and an aquaculture strain from a local fish farm), fish from a blue tilapia assemblage in the New River, and redbelly tilapia from the New River. The best survival at cold temperatures was observed with the wild Mozambique tilapia, while the aquacultural strain of Mozambique tilapia was the best performer overall for all salinities at warm temperatures. The blue tilapia strain surprisingly did not have better survival than Mozambique tilapia in cold conditions. Redbelly tilapia results were equivocal, due to other sources of mortality in captivity. While most strains and species had moderately good survival in 45 ppt and 60 ppt conditions at warm temperatures, all species showed poor survival in hot high-salinity (60 ppt) conditions.

Desert Pupfish

Desert pupfish are listed as an endangered species under both Federal and California Endangered Species Acts. They currently inhabit the agricultural drains and creeks that feed into the Salton Sea, shallow areas of the Sea itself, and numerous created refuge habitats. A study of IID agricultural drains found abundance of desert pupfish positively correlated with western mosquitofish, salfin molly, and Mozambique hybrid tilapia (Martin and Saiki 2005). Desert pupfish are observed most frequently in shallow water less than about 1 foot (30 centimeters) deep with velocities less than about 1 foot/second (Black 1980). They are capable of moving freely between the relatively fresh water in the agricultural drains and the highly saline environment in the Salton Sea (DWR and DFG 2007).

Desert pupfish are very tolerant of extreme water quality conditions, and have been held in the laboratory in water with salinity greater than 98 ppt (Barlow 1958, as cited in Moyle 2002). The ability of desert pupfish to tolerate high salinity, high pH, and low DO contributes to their ability to persist at the Salton Sea. Moyle (2002) summarized the life history of desert pupfish as follows, with additional information as noted. This species can tolerate salinities ranging from freshwater to considerably greater than seawater (up to 68 ppt in the wild), DO from saturation to as low as 0.1 to 0.4 mg/L (parts per million), and temperatures from 39.9°F (4.4°C) in winter (Schoenherr 1990) to 108.3°F (42.4°C) in summer (Carveth et al. 2006). Individuals can survive daily temperature fluctuations of up to 78.8°F (26°C) and salinity changes of 10 to 15 ppt. Larvae have a higher salinity tolerance (up to 90 ppt) than do adults (68 ppt) and can withstand sudden salinity changes of up to 35 ppt.

Under current conditions at the Salton Sea, individual desert pupfish inhabiting creeks and drains that flow into the Sea are presumed to move along the Sea's margins and among drains. This movement, which provides the opportunity for genetic exchange among desert pupfish, reduces the potential deleterious effects of isolation of individual populations. It also provides the opportunity to recolonize these same areas in the event a local population is extirpated (DWR and DFG 2007). Therefore, the SCH Project design would include features to maintain connectivity among populations.

Desert pupfish would likely thrive at the SCH ponds, as seen at the Bureau of Reclamation/U.S. Geological Survey Saline Habitat Ponds (Miles et al. 2009). The ponds that had pupfish were mostly less than 1 meter deep and had salinities ranging from 12 to 70 ppt (Miles et al. 2009). Pupfish were the most abundant fish in the Saline Habitat Ponds; over one million were captured when the ponds were drained in late 2010 (personal communication, J. Crayon 2010).

Sailfin Molly and Mosquitofish

Sailfin mollies and mosquitofish are sympatric with desert pupfish in the Salton Sink. Due to their presence in the Colorado River, they also occupy much of the agricultural water supply and drainage systems around the Salton Sea. Like desert pupfish, they demonstrate plasticity in their diet, and tolerance of high water temperature, high salinity, and low oxygen levels. They inhabit the shallow edges of water bodies, usually less than 2 feet deep. As livebearers, they require no special substrate or structure for reproduction.

Desert pupfish, sailfin mollies, and mosquitofish overlap considerably in their trophic roles where they co-exist in the Salton Sink. They would provide diversity and a degree of redundancy in the SCH fish community, which could buffer the effects of perturbation in a dynamic system. Birds that forage for small fish would prey on all three species; however, surface gleaners and skimmers would find sailfin mollies and mosquitofish more accessible, since these fishes are usually active higher in the water column than are desert pupfish.

Threadfin Shad

Threadfin shad form schools near the surface in open water. They can live in seawater but do not reproduce at that salinity. Spawning takes place in open water near floating or partially submerged objects to which the fertilized eggs stick. Threadfin shad feed heavily on larger zooplankton and can greatly reduce the abundance of these organisms (Moyle 2002).

Filling and Stocking of SCH Ponds

The SCH ponds would be stocked with fish species currently in the Salton Sea Basin and captured from local drainages. The initial SCH aquatic community would be comprised of four primary types of fish: tilapia, sailfin molly, mosquitofish, and desert pupfish. Unintentional invasion of other fish from the river waters, such as common carp (*Cyprinus carpio*), various Centrarchid species, red shiners (*Cyprinella lutrensis*), and threadfin shad, may also occur. All but the shad would be unable to survive in waters above 20 ppt salinity.

Following construction, the SCH ponds would be filled with water for the first time and allowed to "season" for a period of several weeks while undergoing various stages of chemical and biological succession. Water chemistry would fluctuate as compounds leach from the newly wetted soils and microbial communities are initiated. Once phyto- and zooplankton are established and salinity exceeds 20 ppt, fish could be introduced, starting with sailfin mollies and mosquitofish.

The first fishes introduced would likely be small species. Sailfin mollies are ubiquitous in the Salton Sea and the agricultural drains surrounding it. They could be easily trapped/and or seined for stocking into SCH ponds. The most productive collection of sailfin mollies would take place in the spring, when the young-of-the-year would still have an approximately 1:1 sex ratio and have not yet been exhausted by the energetic costs of reproduction. Mosquitofish are numerous in the agricultural drains at the Salton Sea's southern end. They also could be easily trapped and/or seined for stocking, or alternately could be obtained from aquaculture or vector control agencies. Pupfish would be trapped and/or seined from several natural localities and created refuges to insure a good representation of available genetic diversity.

Several species and strains of tilapia are present in the waters of the Salton Sea drainage, and each requires a different approach for securing sufficiently large numbers of founders. Mozambique hybrid tilapia are currently abundant in the Salton Sea and large numbers could easily be captured for stocking into SCH ponds. However, their long-term availability is tenuous with the increasing salinity in the Sea. The same fish is available from local aquacultural facilities, but may not perform as well as wild caught fish, given the selection pressure on the wild population that would likely result in greater tolerance of the Sea's salinity and temperature range (Lorenzi and Schlenk, in preparation). Redbelly tilapia are abundant in drains at the Sea's northern end, particularly those filled by tilewater. These populations should persist, due to the consistency of water quality in those drains, and fish would be available for seining/trapping for SCH ponds in the future. Finally, tilapia resembling blue tilapia are present in the rivers, agricultural drains, and Brawley Wetlands.

The release of tilapia into SCH ponds should only take place after phytoplankton and zooplankton are established. If stocks were from freshwater habitats or held in freshwater while captive, they would be first acclimated to the salinity in the ponds. This acclimation could be done under captive maintenance, or by sequestering in a small part of the ponds and allowing the salinity to gradually rise to pond levels before releasing fish into the larger habitat.

Fish Rearing

Due to ever-increasing salinity and degraded water quality in the Salton Sea, the Mozambique hybrid tilapia population in the Sea may have declined seriously by the time of construction of the SCH ponds. If so, extremely intense predation pressure on the fish initially stocked in the ponds may occur. A supply of fish would be needed for initial stocking of the SCH ponds and possible restocking if severe fish die-offs occur. It would be important to stock fish in sufficient numbers to start a sustainable population in the face of predation. Securing an adequate number of fish for stocking may require producing a generation in captivity from captured wild fish. Tilapia could be collected now from local sources while wild stocks remain and held for captive propagation at one or more of the private licensed aquaculture facilities in the area (within 15 miles of all alternative sites). Several trips (fewer than ten) by small (½ to 1 ton) trucks would be required if cultured fish are to be delivered from an aquaculture facility to SCH ponds.

Physical Cover

Heterogeneity in physical habitat structure could be manipulated in the SCH ponds to enhance cover and refugia for fish from predators and possible thermal fluctuations. Refugia from predators would be necessary to allow a sustainable population of fish to persist in the face of expected heavy predation by piscivorous birds, especially when fishery resources in the Salton Sea decline and disappear. Refugia or cover could be provided by deeper waters or physical structural complexity. Types of cover elements considered include:

Swales and Channels – Having water deeper than 3 feet in proximity to shallower areas would allow fish to disperse into areas where they would be more dispersed and/or less visible due to turbidity. These constructed regions of greater depth would provide this element.

Submerged Aquatic Vegetation – Vegetation could also provide cover from predators, especially for small fish. Widgeon grass (*Ruppia* spp.) is expected to become established in the SCH ponds. This vegetation would likely enhance food supplies by providing more microhabitat structure to support invertebrate diversity and productivity. Widgeon grass establishes from seed and needs sufficient light for photosynthesis to reach the pond bottom. Given the projected turbidity, it would be limited to shallow areas of SCH ponds.

Floating Islands – These artificial structures could be used to provide visual cover and shading for potential thermal refugia. Floating islands could be deployed in different areas, and would likely be most useful in shallower areas where other cover is limited. More information would be necessary to evaluate the applicability and feasibility of floating islands.

While many of these components would be considered part of the initial pond construction, placement and size of floating islands could be manipulated to test habitat function. Monitoring of their effectiveness would be a component of the adaptive management approach for the SCH design and operations.

D.4 Possible Operational Scenarios

Possible operational scenarios are shown in Tables D-2 to D-7. These scenarios are meant to test different concepts for creating sustainable saline habitat for fish and wildlife that minimizes risks of impacts such as fish die-offs, ecotoxicity from selenium, and diseases vectors. Upper and lower extremes of the operational range would be tested to detect any effect of that variable on Project performance. Operational values for each variable could be held constant over time or could be adjusted seasonally according to expected outcomes.

The ranges of operational variables to be tested are as follows:

Salinity – 20-40 ppt.

Storage – Approximately 80 to 100 percent of capacity (the volume would depend on the actual alternative selected and amount of ponds constructed). For example, for a constructed pond complex of 2,400 acres, storage could range from 6,000 to 7,200 acre-feet, assuming an average depth of 3 feet deep over 2,400 acres).

Residence Time – 2 to 32 weeks. This range reflects rate of inflow and outflow.

Fish Species – Fishes considered for initial introduction into SCH ponds would include one or more forms of tilapia, threadfin shad, desert pupfish, sailfin molly, and mosquitofish.

Several constraints and potential impacts were considered in the design of the operational scenarios:

Water Quality Tolerances of Target Fish – The fish species used in the ponds would have to survive and reproduce given the expected water quality conditions, both managed (salinity) and uncontrolled (air temperature, wind mixing, DO) conditions. Tilapia appear to meet many of the requirements for a productive, sustainable fishery resource for piscivorous birds. For some tilapia species or strains, cold tolerance (below 13°C [55°F]) is impaired at higher salinities (Lorenzi and Schlenck, in preparation). Hydrological modeling suggests that water temperatures could drop below 11-13°C (52-55°F) during December through February. DO concentrations could dip below tilapia minimum tolerances. Nutrient concentrations are high in the New and Alamo rivers, due to contributions from agricultural runoff. Water quality modeling suggests high levels of algal growth are possible, along with oxygen deprivation problems that accompany hot weather algal blooms (B. Barry and M. Anderson, University of California Riverside, unpublished data). Also, seasonal anoxia could be more frequent and prolonged in spring (March through May) and fall (October) due to algal blooms.

Relative Selenium Loading – Selenium in river water supplying the ponds could bioaccumulate through the food web from invertebrates and fish to birds (see Appendix I, Selenium Management Strategies). Shorter residence time and lower salinity means greater inputs of river water, which would increase overall selenium loading to the ponds.

Vector Risk – Mosquitoes that breed at the ponds could pose a potential human health risk. The likelihood for mosquito vector impacts is based on (1) breeding season (March through November) and (2) salinity tolerance of mosquito larvae (can survive up to 25 ppt, some reduction in populations between 25-28 ppt, < 28 ppt, reduced population 28-34 ppt, control 35 ppt).

Emergent Vegetation Control – The SCH ponds would be managed using elevated salinity to reduce establishment of emergent vegetation, such as cattails and bulrush. Most vegetation is inhibited by 10 ppt salinity, but some strains could tolerate salinities up to 35 ppt (Table D-2).

Table D-2 Constant Salinity (20 ppt) and Constant Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1a	**Constant Salinity (low range), Constant Storage**												
Operating Variables	Salinity (ppt)	20	20	20	20	20	20	20	20	20	20	20	20
	Storage (% capacity)	100	100	100	100	100	100	100	100	100	100	100	100%
	Residence time (weeks)	4	4	4	4	4	4	4	4	4	4	4	4
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	High relative selenium loading											
	Mosquito vector relative risk[2]	High	Low mosquito risk				High mosquito risk						
1b	Residence time (weeks)	16	16	16	16	16	16	16	16	16	16	16	16
	Selenium loading[1]	Medium relative selenium loading											

1. Relative selenium loading – shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

	Salinity range ppt 10-19	20-29	30-39	40-50
Residence Time 4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

Table D-3 Constant Salinity (35 ppt) and Constant Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	**Constant Salinity (high range), Constant Storage**												
Operating Variables	Salinity (ppt)	35	35	35	35	35	35	35	35	35	35	35	35
	Storage (% capacity)	100	100	100	100	100	100	100	100	100	100	100	100
	Residence time (weeks)	16	16	16	16	16	16	16	16	16	16	16	16
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	Low relative selenium loading											
	Mosquito vector relative risk[2]	Low mosquito risk											

1. Relative selenium loading – shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

Residence Time	Salinity range ppt 10-19	20-29	30-39	40-50
4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

Table D-4 Variable Salinity (20-35 ppt) and Variable Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	**Variable Salinity, Variable Storage**												
Operating Variables	Salinity (ppt)	20	20	20	20	20	20	25	30	35	35	30	25
	Storage (% of capacity)	100	100	100	100	100	95	90	85	80	80	90	95
	Residence time (weeks)	8	6	4	4	6	8	10	12	16	16	12	10
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	High relative selenium loading						Med-ium	Low relative selenium loading				Med-ium
	Mosquito vector relative risk[2]	High	Low mosquito risk				High	Medium		Low risk		Medium	

1. Relative selenium loading – shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

Residence Time	Salinity range ppt 10-19	20-29	30-39	40-50
4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

Table D-5 Variable Salinity (20-35 ppt) and Constant Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4	**Variable Salinity, Constant Storage**												
Operating Variables	Salinity (ppt)	20	20	20	20	20	20	25	30	35	35	30	25
	Storage (% capacity)	100	100	100	100	100	100	100	100	100	100	100	100
	Residence time (weeks)	8	6	4	4	6	8	10	12	16	16	12	10
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	High relative selenium loading						Medium		Low relative selenium		Medium	
	Mosquito vector relative risk[2]	High	Low mosquito risk				High	Medium		Low		Medium	

1. Relative selenium loading – shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

Residence Time	Salinity range ppt 10-19	20-29	30-39	40-50
4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

Table D-6 Highly Variable Salinity (20-40 ppt) and Constant Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
5	**Variable Salinity, Constant Storage**												
Operating Variables	Salinity (ppt)	20	20	20	20	20	20	30	40	40	40	40	30
	Storage (% capacity)	100	100	100	100	100	100	100	100	100	100	100	100
	Residence time (weeks)	12	10	8	8	10	12	16	20	20	20	20	16
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	High relative selenium loading				Medium		Low	Lower relative loading				Low
	Mosquito vector relative risk[2]	High	Low mosquito risk				High	Med-ium	Low				Med-ium

1. Relative selenium loading – shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

Residence Time	Salinity range ppt 10-19	20-29	30-39	40-50
4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

Table D-7 Highly Variable Salinity (20-40 ppt) and Variable Storage Operational Scenario

	Scenario Name	Water Year Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
6	**Variable Salinity, Variable Storage**												
Operating Variables	Salinity (ppt)	20	20	20	20	20	20	30	40	40	40	40	30
	Storage (% capacity)	100	100	100	100	100	95	90	85	80	80	90	95
	Residence time (weeks)	12	10	8	8	10	12	16	20	16	20	20	16
Potential Constraints and Impacts	Dissolved oxygen	Anoxia					Anoxia more common						
	Fish temperature tolerance			Potentially too cold									
	Selenium loading[1]	High relative loading				Medium		Low	Very Low relative loading				Low
	Mosquito vector relative risk[2]	High	Low mosquito risk				High	Med-ium	Low				Med-ium

1. Relative selenium loading –shorter residence time and lower salinity means greater inputs of river water, which increases selenium loading.

2. Vector risk of mosquitoes based on salinity tolerance (survive <28 ppt, reduced population 28-34 ppt, control 35 ppt) and breeding season (Mar-Nov).

Relative Selenium Loading

Residence Time	Salinity range ppt 10-19	20-29	30-39	40-50
4-8 weeks	Higher	High	Medium	Low
10-16 weeks	High	Medium	Low	Lower

D.5 Testing Operational Scenarios

Different operational scenarios would be tested in the proof-of-concept period for approximately 10 years (estimated 2015–2025). Two or more operational scenarios would be implemented simultaneously in separate ponds, and outcomes monitored to test performance in meeting objectives and minimizing impacts. Key indicators of important physical, water quality, and biological attributes would be monitored.

Certain indicators of flow and water quality would be frequently monitored to guide daily or weekly pond operations. These operational triggers include pumping or inflow rates of river water and saline water, outflow rates, and salinity of water at inflow and in ponds.

Indicators of Project performance would be identified based on the SCH objectives. Thresholds or desired conditions for each indicator would be defined, and progress toward meeting those objectives measured according to the Monitoring and Adaptive Management Framework (Appendix E). For example, measuring abundance and community composition of fishes in different ponds would be an indicator of SCH Project effectiveness at providing foraging habitat for piscivorous birds (Objective 1) and creating sustainable aquatic habitat (Objective 3).

D.6 Maintenance Activities

SCH Project implementation would also include standard maintenance that would not be varied experimentally. These types of operations would include:

- Sedimentation basin operations;
- Infrastructure maintenance;
- Erosion control structure maintenance;
- Vegetation control; and
- Vector control (see Appendix F, Mosquito Control Plan).

D.6.1 Sedimentation Basin Operations

There would be two sedimentation basins. Operation and maintenance would occur throughout the year and at the end of the year. One basin would be operated at any given time, storing water and settling sediment. The other basin would be drained of water, the sediment dried, and sediment excavated down to original design elevation. Excavated sediment would be used on the Project to maintain berms, offset settling of berms, and create additional habitat islands if necessary.

D.6.2 Infrastructure Maintenance

Monitoring of physical structures would be conducted on a regular basis to check condition, and and maintenance or repairs implemented on an ongoing basis as needed. Project infrastructure for the water supply includes pumps, pump facilities and pipelines and inlet structures. Infrastructure for the water control structures includes culverts, gates, and weirs between ponds and from the ponds to the Salton Sea.

D.6.3 Erosion Control

Berm structure, riprap, and roadways on the crown would be checked periodically for seepage, cracking, erosion, and extensive burrowing by animals. Areas that would potentially receive more wave action due to extended wind fetch would receive closer scrutiny. Typical maintenance activities could include adding riprap, filling cracks or eroded areas, or spreading gravel on the roadway.

D.6.4 Vegetation Control

Unwanted vegetation at SCH infrastructure could include cattails, tules and salt cedar. Measures would be implemented to control vegetation on berms that could compromise structural integrity. Vegetation would also be removed from the sedimentation basin, interception ditch, and around the river pump station to maintain storage and flow capacity. Best management practices for vegetation control would be implemented as appropriate, including but not limited to physical removal and chemical control appropriate near waterways.

D.7 Emergency Operations

Under certain circumstances, it may be necessary to enact rapid response operations in response to a sudden threat or emergency, such as:

- Avian disease outbreak;
- Rapid drawdown of ponds for emergency actions; and
- Mosquito-borne diseases (see Appendix F, Mosquito Control Plan).

D.7.1 Avian Disease Outbreak

Birds would be monitored regularly for signs of disease outbreaks, and monitoring would be intensified if signs of disease are present. Dead and dying birds would be collected to disrupt cycles of infectious diseases. Potentially infectious carcasses would be incinerated at the Sonny Bono Refuge. For diseases that can be treated, such as the early stages of botulism, sick birds would be collected for rehabilitation and release, as is currently done on the Salton Sea.

D.7.2 Pond Drawdown

Under certain conditions it may become necessary to rapidly reduce water elevations a pond, such as emergency repair of water control structures or berms, sudden change in pond water quality, or noxious species control. The drawdown would involve raising the flashboards on the outlet control structure(s) to release water to the Sea. Draining of the ponds could occur as a result of a breach in one or more berms, but complete draining would not be utilized as a typical pond management action. Under certain emergency conditions, such as a pesticide spill in the SCH source waters, or to eradicate a noxious aquatic invader, SCH ponds could be deliberately drained. In such an event, low areas of the ponds' would retain water and act as temporary refugia for fish by design, by allowing either the salvage of the remaining fish or leaving fish in place as recruitment stocks for re-establishing fish populations.

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